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Mountain Goat Population Monitoring and Survey Technique Development

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Alaska Department of Fish and Game Division of Wildlife Conservation

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Cover Photo: Photograph of an adult male mountain goat (LG-157) near Lions Head Mountain, August 2012

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INTRODUCTION

This annual progress report was prepared to meet the reporting requirements for United States Forest Service (USFS). In 2009, the USFS provided funding to support mountain goat aerial survey technique development and population monitoring field activities. Between 2005-2011, Alaska Department of Fish and Game (ADFG) and collaborators have conducted research on this and other topics as part of an independent studies funded by ADFG, Alaska Department of Transportation and Public Facilities (ADOT/PF), Bureau of Land Management (BLM) and Coeur Alaska, and the City of Sitka (see White et al. 2011a, White et al. 2011b, White et al. 2012). This report summarizes activities associated with the USFS contract that have been completed by December 31, 2012 (but also includes relevant survey technique development research conducted since 2005).

Background

Monitoring the abundance and productivity of mountain goat populations is critical for evaluating the effects of forest management practices, including timber harvest, helicopter tourism, and mining activities. Mountain goats are designated a management indicator species under USFS policy yet actual monitoring has, historically, been very limited. Aside from routine surveys conducted by ADFG in high-use hunting areas, long-term, consistent monitoring data is absent; especially in areas where intensive helicopter tourism is prevalent. Compounding this problem are complexities associated with estimating actual population size from raw survey data. A common approach for calculating actual population size involves developing mark-resight or logistic regression based "sightability" models. Such models can then be used to calculate actual population size by statistically accounting for sources of environmental and survey bias recorded in routine surveys. Unfortunately, such models have not been developed for mountain goats in southeastern Alaska and, as a result, the ability to accurately monitor mountain goat populations is limited. This study aims to develop mountain goat "sightability" models to address this important limitation of monitoring efforts.

STUDY OBJECTIVES

This research is designed to investigate sources of mountain goat aerial survey bias (ie. behavioral, environmental and climatic) in order to develop statistical and field techniques needed to accurately estimate mountain goat population size during routine monitoring surveys. The specific objectives are as follows:

1) estimate individual mountain goat sighting probabilities under a range of different conditions (i.e., to determine which habitat conditions/circumstances result in the highest/lowest chance of seeing goats), and

2) estimate population sightability estimates for a given survey under a given set of conditions (i.e., proportion of animals seen during a survey).

STUDY AREA AND METHODS

Study Design Overview

Beginning in 2005, the Alaska Department of Fish and Game (with funding from ADOT/PF and Coeur Alaska) initiated a broad-based mountain goat ecology study in the Lynn Canal area (White et al. 2012). Later, in 2009, ADFG initiated a small-scale research project on the lower Cleveland Peninsula, north of Ketchikan (White et al. 2010). And, in 2010, ADFG initiated additional research projects in the Haines/Skagway area (funded by ADFG and BLM; White et al. 2011a) and on central Baranof island (funded by ADFG and City of Sitka; White et al. 2011b). A key aspect of each of these projects has involved deployment of radio-collars on mountain goats to address various study objectives (i.e., habitat selection, movement patterns, vital rates, population estimation). Deployment of radio-collars on mountain goats in these areas has provided an additional opportunity to conduct research relating to mountain goat aerial survey technique development. As such, the focus of this specific project (jointly funded by the USFS) has been to gather field data to develop statistical models and field protocols that can be used in a management context to

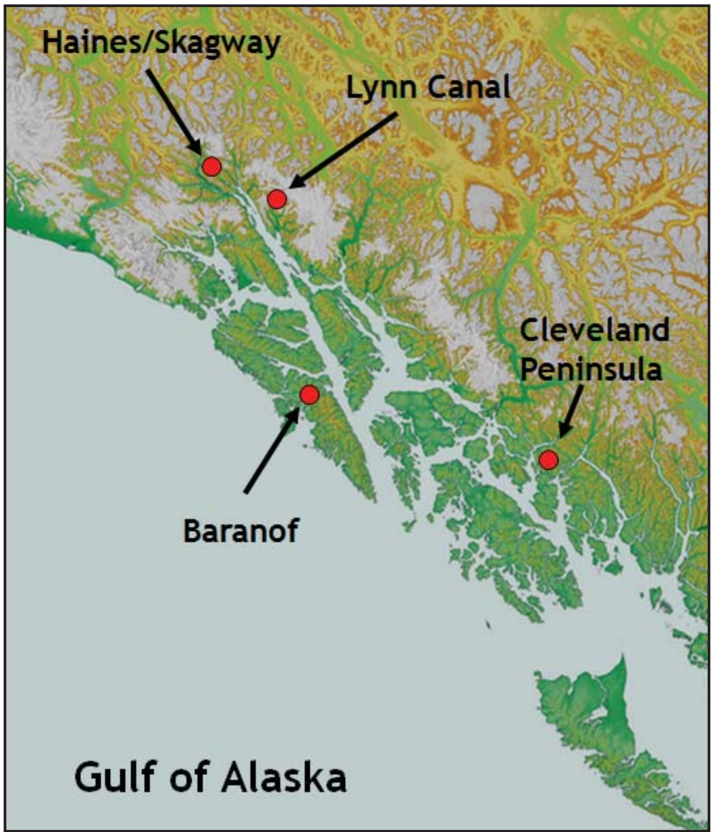

Figure 1: Location of radio-marked mountain goats (n = 90) in southeastern Alaska, as of September 2012 (Lynn Canal: n = 32, Haines/Skagway: n = 27, Baranof: n = 23, Cleveland Peninsula: n = 8).

monitor mountain goat populations in the future throughout southeastern Alaska. The basis of these efforts involves conducting routine aerial surveys in areas inhabited by radio-marked mountain goats and, subsequently, gathering site-specific information about factors that influence the probability of sighting mountain goats on a given survey and/or under certain circumstances. While funding for this project specifically involves gathering data from radio-marked animals collected during aerial surveys, information is also provided about activities associated with deployment of radio-collars (that was funded from other sources, as described).

Study Area

Mountain goats were studied in 4 separate study areas in southeastern Alaska (Figure 1), as described above. In general, the overall area has a maritime climate that is characterized by cool, wet summers and relatively warm snowy winters. Annual precipitation at sea-level averages 55-155 inches and winter temperatures are rarely less than 5º F and average 30-35º F. Elevations at 2600' can receive ca. 250 inches of snowfall, annually (Eaglecrest Ski Area, Juneau, AK, unpublished data). Predominant vegetative communities occurring at low-moderate elevations (<1500') include Sitka spruce (*Picea sitchensis*)-western hemlock (*Tsuga heterophylla*) coniferous forest, mixed-conifer muskeg and deciduous riparian forests. Mountain hemlock (*Tsuga mertensiana*) dominated 'krummholtz" forest comprises a subalpine, timberline band occupying elevations between 1500-2500 feet. Alpine plant communities are composed of a mosaic of relatively dry ericaceous heathlands, moist meadows dominated by grasses and forbs and wet fens. Avalanche chutes are common in the study area, bisect all plant community types and often terminate at sea-level.

Mountain Goat Capture

Mountain goats were captured using standard helicopter darting techniques and immobilized by injecting 3.0 - 2.4mg of carfentanil citrate, depending on sex and time of year (Taylor 2000, White and Barten 2009), via projectile syringe fired from a Palmer dart gun (Cap-Chur, Douglasville, GA). During handling, all animals were carefully examined and monitored following standard veterinary procedures (Taylor 2000) and routine biological samples and morphological data collected. All animals were equipped with red or orange-colored GPS (Telonics TGW-3590) and/or VHF radio-collars (Telonics MOD-500, MOD-410; Figure 2). Following handling procedures, the effects of the immobilizing agent was reversed with 100mg of naltrexone hydrochloride per 1mg of carfentanil citrate (Taylor 2000). All capture procedures were approved by the State of Alaska Animal Care and Use Committee.

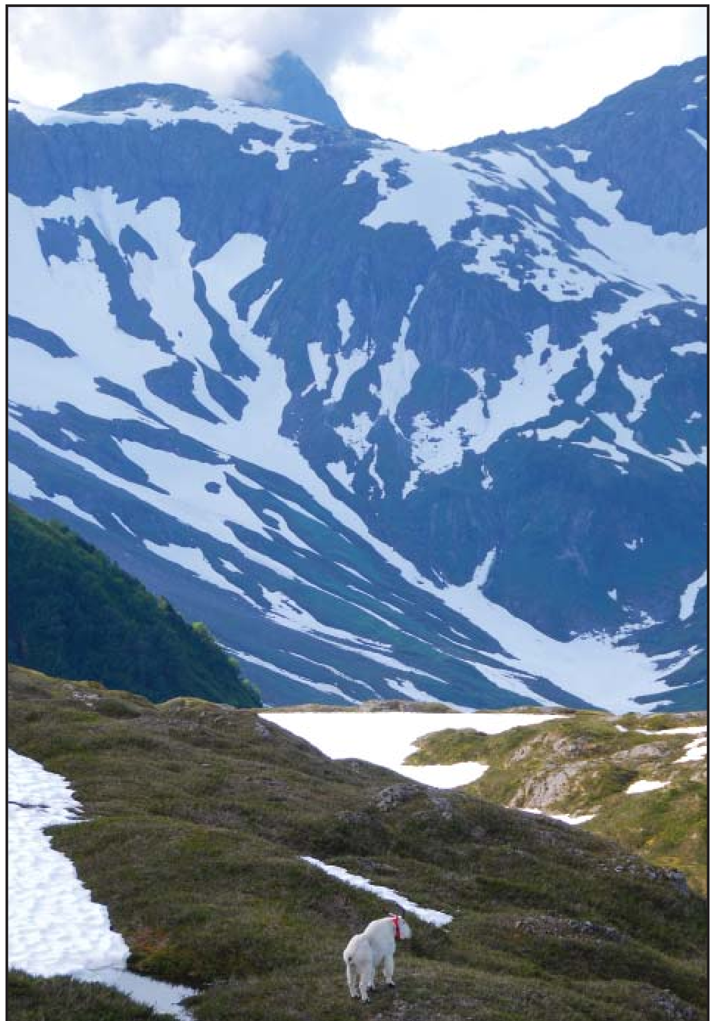

Figure 2: Photograph of a radio-marked adult male mountain goat (BG-22, 14-yrs old) in the upper Clear river watershed on Baranof Island, illustrating the types of habitat and ruggedness of the terrain inhabited by mountain goats in the study area, August 2012.

Aerial Survey Technique Development Data Collection

Aerial Surveys.—Population abundance and composition surveys were conducted using fixed-wing aircraft (Helio-courier and PA-18 "Super Cub") and helicopter (Hughes 500) during August-October 2006-2010. Aerial surveys were typically conducted when conditions met the following requirements: 1) flight ceiling above 5000 feet ASL, 2) wind speed less than 20 knots, 3) sea-level temperature less than 65 degrees F. Surveys were typically flown along established flight paths between 2500-3500 feet ASL and followed geographic contours. Flight speeds varied between 60-70 knots. During surveys, pilots and experienced observers enumerated and classified all mountain goats seen as either adults (includes adults and sub-adults) or kids. In addition, each mountain goat group observed was checked (via 14X image stabilizing binoculars) to determine whether radio-collared animals were present.

Sightability Data Collection.-During aerial surveys, data were simultaneously collected to evaluate individual- and survey-level "sightability". For accomplishing survey-level objectives, we enumerated the number of radio-collared animals seen during surveys and compared this value to the total number of radio-collared animals present in the area surveyed. To gather individual-based "sightability" data, we characterized behavioral, environmental and climatic conditions for each radio-collared animal seen and not seen (i.e., missed) during surveys. In cases where radio-collared animals were missed, it was necessary to back-track and use radio-telemetry techniques to locate animals and gather associated covariate information. Since observers had general knowledge of where specific individual radio-collared animals were likely to be found (i.e., ridge systems, canyon complexes, etc.), it was typically possible to locate missed animals within 5-15 minutes after an area was originally surveyed. In most cases, it was possible to completely characterize behavioral and site conditions with minimal apparent bias, however in some cases this was not possible (i.e., animals not seen in forested habitats, steep ravines, turbulent canyons) and incomplete covariate information was collected, resulting in missing data.

RESULTS AND DISCUSSION

Mountain Goat Capture and Handling

Capture Activities.—Mountain goats were captured during August-October in 2005-2012. Overall, 250 animals (108 females and 142 males) were captured using standard helicopter darting methods. Due to programmed GPS-collar self-release or natural mortality, by the fall 2012 aerial survey season 90 animals were deployed with radio-collars in 4 separate study areas (Figure 1).

Aerial Survey Technique Development Data Collection

Aerial Survey Training Manual.—An aerial survey training manual was produced in order to ensure that moderately complicated aerial survey protocols could be consistently implemented by different observers. The manual focuses on describing specific field protocols, illustrating each habitat classification type and providing test cases to enable prospective observers to test their proficiency and calibrate their responses to other observers (White and Pendleton 2010). The manual is intended to be a working document and will be revised in the future as additional images and materials become available.

Aerial Surveys.—Overall, 20 aerial surveys were conducted during September 2012 (Table 1). During nearly all of these surveys (n = 19), data were collected for purposes of developing individual-based and population-level sighting probability models. Aerial surveys were conducted in all

Table 1. Categorical covariate summary, including proportion of animals seen under each sub-category, for mountain goat sightability trials (n = 415) conducted in southeastern Alaska, 2007-2012.

Variable	Category	Seen	Missed	Total	Prop Seen	SE
Group Size						
	1	95	59	154	0.62	0.04
	2-3	80	40	120	0.67	0.04
	4-5	29	10	39	0.74	0.07
	6-10	28	0	28	1.00	0.00
	11-15	8	0	8	1.00	0.00
	16-20	3	0	3	1.00	0.00
	21-40	4	0	4	1.00	0.00
Behavior						
	Bedded	108	34	142	0.76	0.04
	Feeding	23	12	35	0.66	0.08
	Running	6	0	6	1.00	0.00
	Standing	58	36	94	0.62	0.05
	Walking	48	25	73	0.66	0.06
Landform						
	Ridge	46	24	70	0.66	0.06
	Mid-Slope	154	80	234	0.66	0.03
	Ravine	41	55	96	0.43	0.05
Slope						
	Flat	3	1	4	0.75	0.22
	Gentle	19	8	27	0.70	0.09
	Moderate	91	45	136	0.67	0.04
	Steep	91	46	137	0.66	0.04
	Very Steep	36	58	94	0.38	0.05
Terrain						
	Smooth	50	10	60	0.83	0.05
	Broken	157	95	252	0.62	0.03
	Very Broken	35	55	90	0.39	0.05
Habitat						
	Meadow	102	14	116	0.88	0.03
	Rocky	109	60	169	0.64	0.04
	Subalpine Fst.	15	30	45	0.33	0.07
	Thicket	10	26	36	0.28	0.07
	Snow	4	25	29	0.14	0.06
	Mature Fst.	0	10	10	0.00	0.00
Lighting						
	Overcast	140	91	231	0.61	0.03
	Sun	68	47	115	0.59	0.05
	Shade	34	29	63	0.54	0.06
% Canopy Cover						
	0	157	82	239	0.66	0.03
	1-5	1	1	2	0.50	0.35
	6-25	7	6	13	0.54	0.14
	26-50	6	5	11	0.55	0.15
	51-75	7	12	19	0.37	0.11
	76-95	0	10	10	0.00	0.00
	96-100	0	21	21	0.00	0.00
Dist to Terrain Obs (m)						
	0	3	8	11	0.27	0.13
	1-10	85	67	152	0.56	0.04
	11-25	41	13	54	0.76	0.06
	26-50	20	11	31	0.65	0.09
	51-100	18	3	21	0.86	0.08
	100-200	7	2	9	0.78	0.14

four study areas.

Individual-based Sightability Data Collection.-During 2012, habitat and behavioral covariate data were collected for 86 marked mountain goat observations during aerial surveys. These data were paired with records of whether animals were seen or not seen during routine surveys in order to compile a database suitable for determining factors related to mountain goat survey sighting probability. Overall, data has been collected during 415 "sightability trials" involving marked mountain goats between 2007-2012.

Survey-level Sightability Data Collection.-During 2012, nineteen aerial surveys were conducted that provided adequate data for estimating survey-level sightability (Appendix 1). Survey-level sighting probability estimates ranged between 0.25-1.00; however, sample sizes were generally too small for meaningful comparisons between individual surveys.

Comparison of sighting probabilities between study areas and years revealed substantial variation (Table 2). In particular, sighting probabilities at the Cleveland Peninsula site were markedly lower than elsewhere; however, samples sizes are low. Mountain goats on the Cleveland Peninsula tend to utilize forested habitats more frequently than in other areas and such behavior likely accounts for low sighting probabilities in that area. In addition, inter-annual variation in sighting probabilities were also evident within specific study areas. Such variation is likely due to differences in survey conditions between years.

Statistical Analyses.-Preliminary analyses of individual- and survey-level data were described in White and Pendleton (2011). Briefly, logistic models were fit using Bayesian procedures (Program OpenBUGS) to predict sighting probability as a function of individual and survey-level covariates. Preliminary results of individual-level sighting probability models have been used to simplify field data collection (i.e., collecting data on only the most important variables). Preliminary population-level models have been used to derive relatively precise population estimates for the Lynn Canal study area (White et al. 2012). Nonetheless, additional refinements of models incorporating data collected in 2012 are expected to further improve model performance.

Table 2: Summary of sighting probabilities detected during mountain goat aerial surveys conducted in 4 seperate study areas, 2010-2012, southeastern Alaska.

Area	Seen	Total	Prop. seen	SE
Baranof				
2010	--	--	--	--
2011	12	18	0.67	0.11
2012	11	21	0.52	0.11
Total	23	39	0.59	0.08
Cleveland Pen				
2010	--	--	--	--
2011	--	--	--	--
2012	3	16	0.19	0.10
Total	3	16	0.19	0.10
Haines-Skagway				
2010	14	20	0.70	0.10
2011	20	32	0.63	0.09
2012	8	18	0.44	0.12
Total	42	70	0.60	0.06
Lynn Canal				
2010	39	73	0.53	0.06
2011	19	28	0.68	0.09
2012	21	32	0.66	0.08
Total	79	133	0.59	0.04
Overall total	215	383	0.56	0.03

FUTURE WORK/RECOMMENDATIONS

Individual- and population-level sightability data sets are not yet adequate for complete statistical analyses and additional data collection efforts are needed. Currently, 90 mountain goats are deployed with radio-collars in four study areas throughout southeastern Alaska. Additional radio-collar deployment efforts are planned for late-summer 2013 and will occur in the Lynn Canal and, possibly, the Baranof and Haines-Skagway study areas. A significant opportunity exists to continue mountain goat aerial survey technique data collection efforts in multiple areas throughout southeast Alaska. Currently, funding is available to maintain the current level of survey effort during 2013. In addition, during 2013, efforts will continue to further develop and refine statistical methods for analyzing mountain goat aerial survey data.

PROJECT PUBLICATIONS

Pendleton, G. W., and K. S. White. 2010. Covariate-based detectability models for repeated aerial surveys. Abstract. Wildlife Society Conference, Snowmass, UT.

White, K. S. and G. Pendleton. 2009. Mountain goat population monitoring and survey technique development. Research Progress Report. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

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Appendix 1: Summary of mountain goat aerial surveys conducted in 2012 in order to gather data needed to develop sighting probability models. Preliminary sighting probability estimates are provided for each survey in addition to sample size of marked animals and survey conditions.

Study Area	Date	Temp	Weather	Wind	Collars Seen	Total Collars	Sighting Prob
Lynn Canal							
Lions Head	9/19/12	40-44	High Overcast	0-10	7	8	0.88
Sinclair Mtn.	9/19/12	40-44	High Overcast	0-10	5	9	0.56
B-L Ridge	9/19/12	43	High Overcast	0-5	3	3	1.00
East Berners	9/19/12	42-43	High Overcast	0-5	3	6	0.50
Grandchild Pks	9/20/12	57-58	Clear	0-10N	2	3	0.67
Mt. Villard	9/21/12	49-51	High Overcast	0-5	1	3	0.33
Haines-Skagway							
Porcupine	10/1/12	35	High Overcast	10-20N	1	4	0.25
Takhin	10/1/12	31	Clear	10-20N	1	4	0.25
Chilkoot[1]	9/21/12	50	High Overcast	0-5	1	2	0.50
Chilkoot[1]	9/22/12	54	Mostly Clear	10-30S	0	0	--
Chilkoot[1]	10/1/12	32	High Overcast	0-15N	0	1	0.00
Takshanuk[1]	9/22/12	49	Mostly Clear	0-15S	5	6	0.83
Takshanuk[1]	10/1/12	28-30	High Overcast	0-15N	0	1	0.00
Baranof							
Blue Lake	10/2/12	35	Mostly Clear	0-5	1	8	0.13
Katlian	10/2/12	35	High Overcast	0-5	6	8	0.75
Nakawasina	10/2/12	35	High Overcast	0-5	1	2	0.50
N Carbon	10/2/12	35	High Overcast	0-5	1	1	1.00
Baranof River	10/2/12	35	High Overcast	0-5	2	2	1.00
Cleveland Pen							
Cleveland	9/25/12	47	Clear		2	8	0.25
Cleveland	10/2/12	34-39	Clear	10N	1	8	0.13
Total					43	87	0.49

[1] partial survey (route completed on multiple days)